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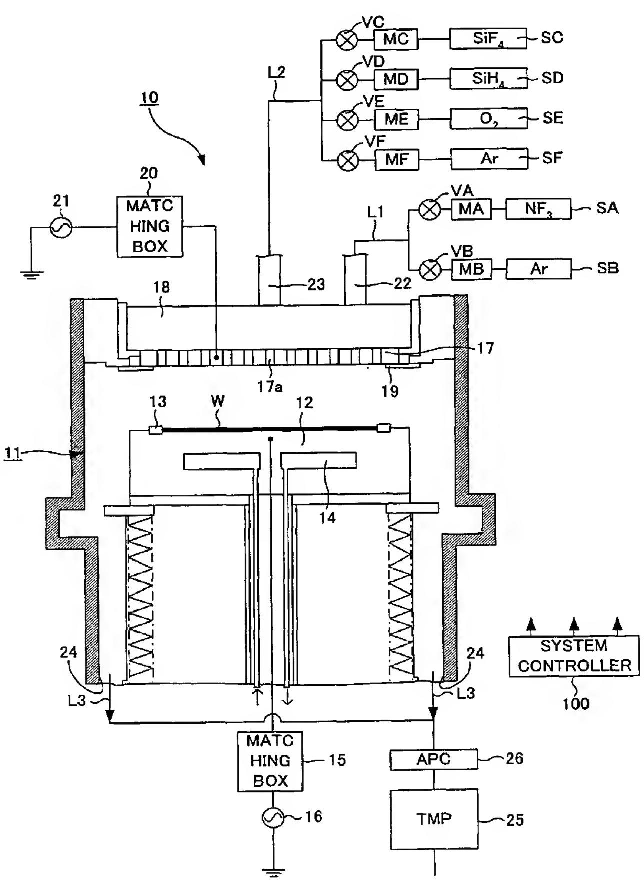
(54) **Title:** PROCESSING APPARATUS AND CLEANING METHOD



(57) **Abstract:** Provided is a parallel-plate-type processing apparatus (10), which performs plasma CVD and includes a chamber (11) to be cleaned. To perform cleaning of the chamber (11), plasma of a gas including fluorine is generated outside the chamber (11), and supplied into the chamber (11). During the cleaning, an RF power is applied to electrode plates (12, 17) inside the chamber (11).

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DESCRIPTION

PROCESSING APPARATUS AND CLEANING METHOD

Technical Field

The present invention relates to a processing apparatus and a cleaning method in which an efficient cleaning is possible.

Background Art

Various CVD (Chemical Vapor Deposition) apparatuses are used for manufacturing electronic devices, such as semiconductor devices, LCD (Liquid Crystal Display) devices, etc. Plasma CVD apparatuses are widely used for forming high quality films.

The plasma CVD apparatus forms a film on a semiconductor wafer contained inside a decompressed chamber, using a CVD method. The CVD method employs a gas phase reaction. Thus, films are formed only on the surface of the wafers, but on the surface (internal wall, etc.) of a chamber member. Thus formed films cause particles to be generated, thereby lowering the yield of the products. In such circumstances, it is necessary to regularly clean the inside of the chamber, to remove the films formed on the chamber member.

A well-known method for cleaning the inside of the chamber is an in-situ plasma cleaning method, wherein a cleaning gas is introduced into the chamber, and plasma is generated from a gas inside the chamber. However, plasma is generated inside the chamber, so that the chamber member is likely to be deteriorated.

A remote plasma cleaning method has been proposed. In this remote plasma cleaning method, plasma of a cleaning gas is generated outside the chamber, and the generated plasma is introduced into the chamber so as to clean the inside of the chamber. Using this remote plasma cleaning method, the chamber member is unlikely to be deteriorated. Such a remote plasma cleaning method is disclosed in Unexamined Japanese Patent Application KOKAI Publication No. H9-69504 (U.S. Priority No. 08/278605).

A problem in the remote plasma cleaning method is that it requires a

relatively long period of time for the cleaning. In the remote plasma cleaning method, the plasma gas is introduced from one or two point(s) into the chamber, so that the inside of the chamber is not evenly cleaned. Using the remote plasma cleaning method, it takes a long time for cleaning entirely the inside of the chamber, resulting that a part of the chamber member is deteriorated due to the excessive cleaning.

Accordingly, in the conventional CVD apparatus, the cleaning of the chamber is not performed with high efficiency, and a high yield of the products is not sufficiently be obtained.

Disclosure of Invention

The present invention has been made in consideration of the above. It is accordingly an object of the present invention to provide a processing apparatus and a cleaning method by which a cleaning with high efficiency is possible.

In order to achieve the above objects, according to the first aspect of the present invention, there is provided a processing apparatus (10) comprising: a chamber (11); a gas source (SA) for supplying a gas for cleaning inside of said chamber (11); a gas line (L1) for introducing the gas supplied from said gas source (SA) into said chamber (11); an activator (27) which is prepared in said gas line (L1) and activates the gas supplied from said gas source (SA); and at least three gas inlets (28) which are provided at a side wall of said chamber (11) and connected to said gas line (L1).

In order to achieve the above objects, according to the second aspect of the present invention, there is provided a method for cleaning a processing apparatus (10) including two electrodes (12, 17) in a chamber (11), said method comprising the steps of: introducing a gas for cleaning into said chamber (11); and applying an RF power to each of the two electrodes (12, 17), thereby activating the gas for cleaning.

Brief Description of Drawings

FIG. 1 is a diagram showing the structure of a processing apparatus according to the first embodiment of the present invention.

FIG. 2 is a diagram showing cleaning results obtained using the processing apparatus of FIG. 1.

FIG. 3 is a diagram showing cleaning results obtained using the processing apparatus of FIG. 1.

FIG. 4 is a diagram showing the structure of a processing apparatus according to the second embodiment of the present invention.

FIG. 5 is a cross sectional view showing the processing apparatus of FIG. 4.

FIG. 6 is a diagram showing cleaning results obtained using the processing apparatus of FIG. 4.

FIG. 7 is a diagram showing cleaning results obtained using the processing apparatus of FIG. 4.

FIG. 8 is a diagram showing the structure of a processing apparatus according to the third embodiment of the present invention.

FIG. 9 is a diagram showing cleaning results obtained using the processing apparatus of FIG. 8.

FIG. 10 is a diagram showing a processing apparatus as a comparative example.

FIG. 11 is a diagram showing a lid member included in a processing apparatus according to the fourth embodiment.

FIG. 12 is a diagram showing cleaning results obtained using the processing apparatus according to the fourth embodiment.

FIG. 13 is a diagram showing a modification of the lid member included in the processing apparatus according to the fourth embodiment.

FIG. 14 is a diagram showing further cleaning results obtained using the processing apparatus of the fourth embodiment.

FIG. 15 is a diagram showing the lid member as a comparative example as a comparative example.

FIG. 16 is a diagram showing the structure of a processing apparatus according to the fifth embodiment.

FIG. 17 is a diagram showing cleaning results obtained using the processing

apparatus of the fifth embodiment.

FIG. 18 is a diagram showing another structure of the processing apparatus of the fifth embodiment.

FIG. 19 is a diagram showing another structure of the processing apparatus of the fifth embodiment.

Best Mode for Carrying Out the Invention

A processing apparatus according to the first embodiment of the present invention will now be explained with reference to the accompany drawings.

The processing apparatus according to the first embodiment includes a chamber. In this chamber, SiOF films are formed respectively on semiconductor wafers (hereinafter referred to as a wafer W) using a plasma CVD method, with a process gas containing SiH_4, SiF_4 and O_2. The SiOF film remaining in the chamber after the formation is removed therefrom, using a cleaning gas containing NF_3.

First Embodiment

FIG. 1 shows a cross sectional view of a processing apparatus 10 according to the first embodiment of the present invention. As shown in FIG. 1, the processing apparatus 10 comprises a chamber 11, a cleaning gas line L1, a process gas line L2, an exhaust line L3, and a system controller 100.

The cleaning gas line L1 connects the chamber 11 to an NF_3 source SA, serving as a cleaning gas source, and also to an Ar source SB, serving as a carrier gas source. The NF_3 source SA and Ar source SB are connected to the cleaning gas line L1, respectively through mass-flow controllers MA and MB, and also through valves VA and VB. Those lines, for connecting the NF_3 source SA and Ar source SB, and chamber 11 are, connected on vent parts of the valves VA and VB so as to be formed into a single line. In this structure, NF_3 and Ar are mixed at a predetermined ratio by the controllers MA and MB and valves VA and VB, and supplied to the chamber 11.

The process gas line L2 connects chamber 11 to an SiF_4 source SC, an SiH_4 source SD, an O_2 source SE, and to an Ar source SF. The SiF_4 source SC, SiH_4

source SD, O_2 source SE, and Ar source SF are connected to the process gas line L2 respectively through mass-flow controllers MC, MD, ME, and MF, and also through valves VC, VD, VE, and VF. Those lines for connecting the SiF_4 source SC, SiH_4 source SD, O_2 source SE and Ar source SF, and chamber 11 are converged on the vent parts of the valves VC, VD, VE, and VF, so as to be formed into a single line. In this structure, SiF_4, SiH_4, O_2 and Ar are mixed at a predetermined ratio by the mass-flow controllers MC, MD, ME, and MF and also the valves VD, VD, VE, and VF, and supplied to the chamber 11.

The chamber 11 is a reactive chamber which can be decompressed into a vacuum state. The chamber 11 is formed approximately in a cylindrical shape, made of aluminum, etc., and is grounded.

Provided on the side wall of the chamber 11 is a gate for carrying in and out wafers W to and from the chamber 11 through a gate valve. A susceptor 12 is provided in the middle of the chamber 11.

The susceptor 12 made from a conductor such as aluminum, for example, and formed almost in a cylindrical shape. Mounted on the upper surface of the susceptor 12 is a wafer W and an electrostatic chuck which electrostatically absorbs the wafer W so as to fix the wafer W thereonto.

A focus ring 13 is provided on the upper surface of the susceptor 12. In this structure, plasma can effectively contact the wafer W mounted on the susceptor 12. There is provided in the susceptor 12 a lift pin which can go up and down for receiving and providing the wafer.

A chiller room 14 is provided in the susceptor 12. A chiller flows into each of the chiller room 14 through a pipe. The temperature of the susceptor 12 and wafer W on the susceptor 12 is adjusted by the chiller. Note that, a chiller means a temperature controlling medium herein.

The susceptor 12 is connected to the first RF power source 16 through the first matching box 15. One end of the first RF power source 16 is grounded, so that an RF voltage can be applied to the susceptor 12.

An electrode plate 17 is tightened up to an electrode supporter 18 at the

ceiling of the chamber 11. The electrode plate 17 faces and is parallel to the susceptor 12. The electrode plate 17 is formed from a conductor such as aluminum. A Shield ring 19, for protecting the sections of the electrode plate 17 which are fixed to the electrode supporter 18, is provided beneath the peripheral of the electrode plate 17.

The electrode plate 17 is connected to the second RF power source 21 through the second matching box 20. One end of the second RF power source 21 is grounded, so that an RF voltage is applied to the electrode plate 17. Accordingly, the electrode plate 17 and susceptor 12 function respectively as an upper electrode and lower electrode of a parallel-plate-type plasma CVD apparatus.

A cleaning-gas inlet pipe 22 and a process-gas inlet pipe 23 are provided on the upper section of the chamber 11. The cleaning-gas inlet pipe 22 is connected to the cleaning gas line L1, so that a cleaning gas is introduced into the chamber 11 through the cleaning gas inlet pipe 22. The process-gas inlet pipe 23 is connected to the process gas line L2, so that a process gas is introduced into the chamber 11 through the process-gas inlet pipe 23.

The electrode supporter 18 includes a diffusing portion such as a hollow, for diffusing the process gas. The electrode plate 17 has a plurality of holes 17a throughout the electrode plate 17. The cleaning gas and process gas which are diffused by the diffusing portion are sent to the wafer W through the holes 17a of the electrode plate 17.

An annular vent 24 is provided at the bottom of the chamber 11. The vent 24 is connected to the exhaust line L3. The exhaust line L3 is connected to a TMP (Turbo Molecular Pump) 25. A dry pump is provided downstream of the TMP 25, so that the chamber 11 can be decompressed so as to be in a vacuum state. An APC (Automatic Pressure Controller) 26 is provided between the TMP 25 and the chamber 11. The chamber 11 is controlled to be in a predetermined pressure level by the APC 26.

The system controller 11 controls the processing apparatus 10 totally, including a film formation process and a cleaning process which are carried out

inside the processing apparatus 10.

The film formation process and cleaning process carried out by the processing apparatus 10 of the first embodiment will now be explained with reference to FIG. 1. Those procedures included in the above processes will be explained below for description purposes only, and the present invention is not limited to them.

The wafer W is carried into the chamber 11, and put on the susceptor 12. The wafer W is fixed thereon by the electrostatic chuck. The system controller 100 opens the valve VE so as to supply O_2, and applies an RF power to the upper electrode (the electrode plate 17). Subsequently, the system controller 100 opens the valves VC, VD, and VF, supplies the chamber 11 with SiF_4, SiH_4, and Ar, and applies a voltage to the lower electrode (the susceptor 12). From this, plasma of the gas is generated, and the SiOF film formation reaction undergoes on and over the surface of the wafer W.

After the SiOF film having a predetermined thickness is formed on the wafer W, or after a predetermined time, the system controller 100 stops applying an RF power to the lower electrode, and closes the valves VC, VD, and VF, so as to stop supplying the chamber 11 with SiF_4, SiH_4, and Ar. After this, the electrostatic chuck is released. The system controller 100 closes the valve VE so as to stop supplying O_2 and applying an RF power to the upper electrode. Then, the wafer W is carried out from the chamber 11, and hence completing the film formation process.

After the above-described film formation process is done for a predetermined number of wafers, the system controller 100 starts cleaning the chamber 11.

A dummy wafer W for cleaning is carried into the chamber 11, and put on the susceptor 12. The dummy wafer W put on the susceptor 12 is fixed by the electrostatic chuck. Then, the system controller 100 opens the valves VA and VB, and supplies the chamber 11 with NF_3 and Ar.

A cleaning gas is supplied into the chamber 11 at a ratio of NF_3/Ar=500/500 (sccm/sccm). The pressure inside the chamber 11 is set to 13Pa by the APC 26.

After the cleaning gas is thus supplied, the system controller 100 start applying an RF power to the upper and lower electrodes, so as to begin the cleaning. Note that applied to the upper electrode is an RF power of approximately 1500W, and applied to the lower electrode is an RF power of approximately 500W. Upon application of the RF power to the cleaning gas, plasma of the gas especially containing fluorine radical is generated. An NF_3 plasma (containing, mainly, fluorine radical) reacts with SiOF deposited inside the chamber 11, as explained in the following formula. As shown in the following formula, SiOF is decomposed by NF_3, so as to be exhausted as a gas of, for example, SiH_4, etc.

$$SiOF+NF_3 \rightarrow SiF_4 \uparrow +1/2O_2 \uparrow +1/2N_2 \uparrow$$

The system controller 100 monitors a light emission of the plasma generated (for example, of oxygen) during the cleaning process, and detects the end point of the cleaning. As described above, O_2 is generated at the same time of the decomposition of SiOF, and the amount of O_2 changes during the cleaning process. That is, the system controller 100 can detect the end point of the cleaning, by monitoring the amount of oxygen (based on an emission intensity). Note that the end point of the cleaning can be detected by any other methods, such as a method for detecting the pressure inside the chamber, etc.

Upon the end point of the cleaning, the system controller 100 stops applying an RF power to the upper and lower electrodes. Subsequently, the system controller 100 opens the valves VE and VF, supplies the chamber 11 with O_2 and Ar, and starts applying an RF power to the upper electrode. After this, the system controller 100 stops supplying the chamber 11 with Ar and applying the RF power to the upper electrode. The system controller 100 stops supplying the chamber 11 with O_2, and releases the electrostatic chuck. Then, the dummy wafer W is carried out from the chamber 11, thereby completing the cleaning process.

Example 1

FIGS. 2 and 3 show cleaning results achieved after the film formation which is done using the plasma processing apparatus 10 according to the first embodiment of the present invention.

In this Example 1, during a film formation, a SiOF film is formed to have a thickness of 5 μ m on the wafer W, within the distance 50mm between the electrodes. In addition, during a cleaning process, the system controller 100 supplies the chamber 11 with NF_3/Ar=500/500 (sccm/sccm) at a pressure of 13Pa, and applies an RF power of 1500W to the upper electrode (the electrode plate 17).

FIG. 2 shows the relationship between the cleaning time and the applied RF power, in the case where the cleaning is performed with applying the RF power to the upper and lower electrodes using the processing apparatus of the first embodiment. As seen from FIG. 2, it is clear that the processing apparatus which applies the RF power to the upper and lower electrodes can achieve the cleaning at a shorter period of time than the case where the RF power is applied only to the upper electrode. In the case where RF powers of 300W and 500W are applied to the lower electrode, the cleaning time is reduced to 76MIN and 70MIN, respectively. Accordingly, in the processing apparatus of this embodiment which performs the cleaning by applying an RF power not only to the upper electrode, but also to the lower electrode, a high cleaning rate can be obtained, and hence enabling to perform the cleaning with high efficiency.

In the above-described embodiment, the explanations have been made to the pressure inside the processing apparatus according to the first embodiment, wherein the pressure inside the chamber 11 is retained approximately at a pressure of 13Pa. However, the present invention is not limited to the above, and the cleaning may be performed at a higher pressure than the above pressure of 13Pa.

FIG. 3 shows the relationship between the cleaning time and the pressure inside the chamber 11. As obvious from FIG. 3, as compared to the case where the cleaning is done at a pressure of 13Pa inside the chamber11, the cleaning time can be reduced in the case where the pressure is increased to a pressure of 50Pa. Accordingly, a high cleaning rate can be obtained by performing the cleaning at a moderate level of a vacuum inside the chamber 11.

Second Embodiment

A processing apparatus according to the second embodiment includes a

chamber. Inside the chamber, a SiOF film is formed on a wafer W using a plasma CVD method, with a process gas containing SiH_4, SiF_4, and O_2. The SiOF film deposited inside the chamber after the film formation process is removed using a cleaning gas including NF_3. The cleaning gas is activated outside the chamber so as to be used.

FIG. 4 shows the structure of the processing apparatus 10 according to the second embodiment of the present invention. FIG. 5 is a cross sectional view of the processing apparatus 10. In FIGS. 4 and 5, the same components are identified by the same reference numerals.

As shown in FIG. 4, the processing apparatus 10 of the second embodiment includes a cleaning-gas line L4 provided with an activator 27.

The activator 27 is connected to the cleaning gas source SA and the carrier gas source SB respectively through the valves VA and VB and also through mass flow controllers MA and MB. The activator 27 has a plasma generation mechanism. This mechanism activates the gas passing through the activator 27, so as to generate plasma of the gas. Of cleaning gas plasmas, a fluorine radical which is generated from NF_3 is selectively discharged from the activator 27.

As shown in FIG. 5, the branched cleaning gas lines L4 is connected to two cleaning gas inlets 28 which are provided at the side wall of the chamber 11. The two cleaning gas inlets 28 face each other at the inner wall of the chamber 11. The cleaning gas plasma discharged from the activator 27 is introduced into the chamber 11 through the two cleaning gas inlets 28.

Operations of the processing apparatus 10 according to the second embodiment, in the case where the cleaning process is carried out, will now be explained with reference to FIGS. 4 and 5. The following operations will now be described by way of example, and the present invention is not limited to the below.

After the film is formed on a predetermined number of wafers W, the system controller 100 begins the cleaning of the chamber 11.

The dummy wafer W for cleaning is carried into the chamber 11, and put on the susceptor 12. The dummy wafer W on the susceptor 12 is fixed by the

electrostatic chuck. Subsequently, the system controller 100 opens the valves VA and VB, and supplies the chamber 11 with NF_3 and Ar.

The cleaning gas is supplied into the chamber 11 at a ratio of NF_3/Ar=500/500 (sccm/sccm). The pressure inside the chamber 11 during the cleaning is retained in a range between 100Pa and 400Pa by the APC 26.

After the NF_3 gas and Ar gas are supplied into the chamber 11, the system controller 100 activates the activator 27. The activator 27 activates the supplied gas therein to generate plasma of the gas, and then discharges the plasma (containing mainly fluorine radical) to the chamber 11. The SiOF film remaining and adhered to the inside of the chamber 11 is decomposed to SiF_4, etc. by the cleaning gas mainly containing the fluorine radical, so as to be discharged therefrom. Accordingly, the cleaning is thus proceeded, and the SiOF film deposited inside the chamber 11 is removed.

When the system controller 100 determines that the cleaning has been completed based on the emission intensity of oxygen, it inactivates the activator 27. Further, the system controller 100 closes the valves VA and VB, so as to stop supplying the chamber 11 with the cleaning gas. After this, the system controller 100 opens the valves VE and VF, so as to supply O_2 and Ar into the chamber 11. Subsequently, the system controller 100 releases the electrostatic chuck, and stops supplying O_2 and Ar into the chamber 11. After this, the dummy wafer W is carried out from the chamber 11, thereby completing the cleaning process.

Example 2

FIG. 6 shows the relationship between the time for cleaning and the pressure inside the chamber 11, and shows some results of the cleaning done after the film formation, using the processing apparatus according to the second embodiment of the present invention. In Example 2, during the process for forming the film, a SiOF film is formed to have a thickness of 5 μm on the wafer W, with the distance of 50mm between the electrodes.

FIG. 6 shows the results of the cleaning with a variety of pressure levels. As seen from FIG. 6, as compared to the case where the pressure inside the chamber 11

is in a high vacuum state of approximately 0Pa, a high cleaning rate can be obtained if the pressure is within a range between 100Pa and 400Pa. Note also that, in the case where the pressure inside the chamber 11 is approximately 200Pa, the most highest cleaning rate can be obtained. According to the second embodiment wherein the cleaning is performed at a pressure in a range between 100Pa and 400Pa inside the chamber 11, the cleaning can desirably be achieved with high efficiency.

Example 3

In the above-described second embodiment, an RF power may be applied to the upper electrode. This realizes that the cleaning gas (mainly containing fluorine radical) activated outside the chamber 11 can further be activated inside the chamber 11. According to this structure, a high cleaning rate can be obtained.

FIG. 7 shows the relationship between the time for cleaning and the RF power applied onto the upper electrode, in the case where the cleaning is performed after the SiOF film is formed on the wafer W in a thickness of 5 μ m. During the cleaning, an RF power of 500W is applied to the upper electrode, and the pressure inside the chamber 11 is 200Pa.

As obvious from FIG. 7, if the RF power is applied to the upper electrode and a remote plasma gas is used for cleaning the chamber 11, the cleaning is achieved at a cleaning time which is shorter than one fifth of the cleaning time in the case where the RF power is not applied thereto. Accordingly, with applying the RF power to the upper electrode to activate the cleaning gas in the chamber 11, the cleaning with a high cleaning rate is possible.

Note that the cleaning may be performed, while the RF power is applied not only to the upper electrode, but also to the lower electrode.

Third Embodiment

A processing apparatus according to the third embodiment of the present invention includes a chamber. In this chamber, a SiOF film is formed on a wafer W using a plasma CVD method, which employs a process gas containing SiH_4, SiF_4 and O_2. The SiOF film remaining and adhered to inside of the chamber 11, after

the film formation process, is removed using a cleaning gas containing NF_3. The cleaning gas is activated outside the chamber so as to be used.

The processing apparatus according to the third embodiment of the present invention has the same structure as that of the processing apparatus of the second embodiment shown in FIGS. 4 and 5. FIG. 8 shows the structure of the process according to the third embodiment. In FIG. 8, the same components are identified by the same reference numerals as those of FIG. 4.

As shown in FIG. 8, the processing apparatus 10 of this embodiment includes three cleaning gas inlets 28 at the inner wall of the chamber 11. The three cleaning gas inlets 28 are connected to the cleaning gas line L4 respectively. The cleaning gas inlets 28 are provided approximately at equal intervals. The cleaning gas is supplied into the chamber 11 through each of the cleaning gas inlets 28 substantially at the same supply pressure.

Example 4

FIG. 9 shows results of film formation processes and cleaning processes done by the processing apparatus of the third embodiment. In FIG. 9, comparisons are made to the cleaning results done by the processing apparatus of this embodiment. Specifically, the comparisons are made to one case where the cleaning gas spouts in two ways, and the other case where the cleaning gas spouts into the chamber 11 in three ways.

In the process for forming the film, a SiOF film is formed in a thickness of 5 μm on the wafer W with the distance of 50mm between the electrodes. In the cleaning process, the cleaning gas of NF_3/Ar=1000/1000 (sccm/sccm) is supplied into and through the chamber 11 at a pressure of 13Pa.

In an experiment, a plurality of chips on each of which a silicon oxide film is formed are provided respectively on a plurality of points inside the chamber 11. The thickness of the silicon oxide film of each of the chips is measured after cleaning. The cleaning rate at each of the points in the chamber 11 is calculated, based on a reduction in the measured thickness of the silicon oxide film.

The points for measuring the cleaning rate are identified by symbols of I to V,

as illustrated in FIG. 8. For the processing apparatus 10 wherein the cleaning gas spouts in two ways, the cleaning rate is measured at each of the points I to V, as shown in FIG. 10. The chip at the point I is put on the susceptor 12, and the rest of the chips respectively at the points II to V are put on almost the same plane as the susceptor 12.

As seen from FIG. 9, in the case where the cleaning gas is supplied from two points (in two ways), the cleaning rate at the point II, which is farthest from the cleaning gas inlets 28, is lower than the cleaning rate at any other points I, III, IV, and V. In the third embodiment wherein the cleaning gas is supplied from three points (in three ways), the etching rate at the point II is almost equal to or larger than the etching rate at any other points I, III, IV, and V. In consideration of this, in the processing apparatus 10 of the third embodiment thus including the three cleaning gas inlets 28 in the chamber 11, the uniformity of the cleaning rate can be obtained, and the cleaning is performed with high efficiency.

In the above-described third embodiment, the three cleaning gas inlets 28 are provided at equal intervals on the side wall of the chamber 11. However, the cleaning gas inlets 28 may be provided at any other intervals. Further, the number of the cleaning gas inlets 28 is not limited to three, and more than three cleaning gas inlets may be provided.

Fourth Embodiment

A processing apparatus according to the fourth embodiment of the present invention includes a chamber. In this chamber, a SiOF film is formed on a wafer using a plasma CVD method, which employs a process gas containing SiH_4, SiF_4, and O_2. The SiOF film remaining in and adhered to the inside of the chamber after the film formation process is removed by a cleaning gas containing NF_3. The cleaning gas is activated outside the chamber, so as to be used.

The processing apparatus according to the fourth embodiment of the present invention has the same structure as that of the process according to the third embodiment shown in FIGS. 5 and 8. In the processing apparatus 10 of the fourth embodiment, a lid member 29 shown in FIG. 11 is built on each of the three

cleaning gas inlets 28. In this structure, the cleaning gas is introduced into the chamber 11 through the lid member 29.

As illustrated in FIG. 11, the lid member 29 is formed in a rectangular shape, and has five slit-like openings 30. Those five openings 30 are formed in parallel with each other. The size of the lid member 29 is approximately the same as the section of each of the cleaning gas inlets 28. The cleaning gas is supplied into the chamber 11 through the openings 30. The lid member 29 is made of Al_2O_3, for example.

The opening percentage of the lid member 29 is set in a range from 50% to 80%. Note that the opening percentage in this case implies a ratio of the entire area of the openings 30 included in the lid member 29 to the entire area of the lid member 29, i.e. (Opening (%)) = (Entire Area of Openings 30) / (Entire Area of Lid Member 29) $\times 100$.

Example 5

FIG. 12 shows results of cleaning experiments done using the processing apparatus 10 according to the fourth embodiment of the present invention.

The cleaning experiments are performed in the same manner as that of the Example 4. In the film formation process, a SiOF film is formed in a thickness of 5 μ m on the wafer W, with the distance of 50mm between the electrodes. In the cleaning process, the cleaning gas is supplied at a ratio of NF_3/Ar=1000/1000 (sccm/sccm) and pressure of 13Pa inside the chamber 11.

The opening percentage of the lid member 29 is set to 62%. For comparison, the cleaning experiments are done using a plurality of lid members 29 whose opening percentages are 10%, 35%, and 100%, respectively.

Likewise the Example 4, in the cleaning experiments, chips on each of which a silicon oxide film is formed are provided at each of the points inside the chamber 11. The thickness of the silicon oxide film is measured. The cleaning rate at each of the points is obtained by calculating a reduction in the thickness of the silicon oxide film.

The points for measuring the cleaning rate are identified by symbols of I to V,

as shown in FIG. 8. Note that the chip at the point I is put on the susceptor 12, and the rest of the chips at the points II to V are provided on the same plane as the susceptor 12.

As seen from FIG. 12, if the opening percentage of the lid member 29 is 100%, the cleaning rates respectively at the points I to V widely vary. If the opening percentage of the lid member 29 is 10% or 35%, the cleaning rates thereat are quite uniform. However, such cleaning rates, in the case of 10% or 35% of the opening percentage, are not sufficiently high. Alternatively, according to the processing apparatus of the fourth embodiment using the lid member 29 whose opening percentage is 62%, nearly-uniform cleaning rates are highly obtained at each of the points I to V inside the chamber 11.

Accordingly, in the processing apparatus 10 of this embodiment using the lid member 29 whose opening percentage is in a range from 50% to 80%, sufficiently high cleaning rates can be obtained. In addition, the cleaning gas can be supplied into the chamber 11 with uniformity.

In the fourth embodiment, the openings 30 of the lid member 29 are formed in a slit-like shape. However, the shape of the openings 30 is not limited to this. For example, the openings 30 may be formed in a circular shape, a polygonal shape, or any other shapes. Further, the plurality of slit-shaped openings 30 may be included in parallel with each other. In addition, the shape of the lid member 29 is not limited to the rectangular shape, and the lid member 29 may be formed in a circular shape in conformity with the section of the cleaning gas inlets 28.

In the fourth embodiment, the openings 30 of the lid member 29 may be set at a variety of angles, respectively, as shown in FIG. 13. In this structure, the cleaning gas can uniformly spout into the chamber 11.

FIG. 13 shows a state wherein the lid member 29 of FIG. 11 is fixed into the cleaning gas inlet 28. Of five openings 30 of the lid member 29, a central opening 30a forms a path perpendicular to the main surface of the lid member 29. Openings 30b and 30c, except the central opening 30a, form paths diagonally to the main surface. Specifically, the two openings 30b adjacent to the central opening

30a form paths at an angle of 60° with the main surface, whereas the two end openings 30c form paths at an angle of 45° therewith.

In the structure where the lid member 29 includes the openings 30b and 30c forming the paths diagonally to the main surface, the cleaning gas diagonally spouts from the openings 30b and 30c. Hence, the gas spouts evenly from the cleaning gas inlet 28.

Example 6

FIG. 14 shows results of cleaning experiments achieved using the processing apparatus 10 according to the fourth embodiment, including the lid member 29 of FIG. 13.

Those cleaning experiments are done in accordance with the same steps as those of the Example 4. In the film formation process, the SiOF film of 5 μ m is formed on the wafer W, with the distance of 50mm between the electrodes. In the cleaning process, the cleaning gas flows into and through the chamber, at a ratio of NF_3/Ar = 1000/1000 (sccm/sccm) and at a pressure of 13Pa inside the chamber 11.

The opening percentage of the lid member 29 is set to 35%. For comparison, the same cleaning experiment as the experiment of the Example 4 is performed using the lid member 29 including only the vertical openings 30a of FIG. 15.

Likewise the Example 4, in the experiments, the chip on which a silicon oxide film is formed is provided on each of the points inside the chamber 11, and the thickness of the silicon oxide film is measured. The cleaning rate at each of the points is calculated by measuring the reduction in the thickness of the silicon oxide film.

The points for measuring the cleaning rate are identified by the symbols of I to V shown in FIG. 8. The chip at the point I is put on the susceptor 12, and the rest of the chips at the respective points II to V are provided almost on the same plane as the susceptor 12.

As obvious from FIG. 14, in the case where the lid member 29 including only the vertical openings 30a is used, the cleaning rate is the lowest at the point III, and the cleaning rate widely vary at each points I to V. In the case where the lid

member 29 including the diagonal openings 30b and 30c is used, the cleaning rates are approximately the same at the respective points II to V, i.e. except at the point I (on the susceptor 12). Accordingly, with the utilization of the chamber 29 including the openings 30b and 30c forming the paths at predetermined angles (e.g. 45° , 60°), the cleaning gas is supplied in different directions into the chamber 11, thereby enabling to evenly clean the inside of the chamber 11.

In the above examples, the angles of the paths from the diagonal openings 30b and 30c are not limited to 45° and 60° , and may be 70° , 30° , etc. In addition, in accordance with the number of the openings 30, the angles of the paths from the openings 30 may be changed. For example, if the number of the openings 30 is seven, the seven openings 30 may form paths having respectively an angle of 90° , 60° , 45° , and 30° , sequentially from the central one to both end openings.

Fifth Embodiment

A processing apparatus according to the fifth embodiment of the present invention includes a chamber. In this chamber, a SiOF film is on a wafer W using a plasma CVD method, which employs a process gas containing SiH_4, SiF_4 and O_2. The SiOF film remaining and adhered to the inside of the chamber 11 is removed using a cleaning gas containing NF_3. This cleaning gas is activated outside the chamber 11 so as to be used.

The processing apparatus according to the fifth embodiment of the present invention has the same structure as that of the processing apparatus of the second embodiment which is shown in FIG. 4. In the processing apparatus according to the fifth embodiment, the chamber 11 is connected to the process gas line L1, the exhaust line L3, and the cleaning gas line L4.

FIG. 16 shows the processing apparatus 10 according to the fifth embodiment, in section. In FIG. 16, the same components are identified by the same reference numerals as those of FIG. 5. For the sake of simplicity, the gas lines and RF power sources are not illustrated in FIG. 16.

In the processing apparatus 10 shown in FIG. 16, chiller paths 31 are

embedded in the electrode supporter 18 and the side wall of chamber 11. A chiller flows through the chiller paths 31, thereby the internal surface of the chamber 11, especially the electrode plate 17 supported by the electrode supporter 18 and the wall of the chamber 11, are retained at a predetermined temperature. In the cleaning process, the system controller 100 controls the flow system of the chiller so as to adjust the temperature of the chamber 11. In this specification, the term, chiller, implies a fluid material for maintaining the temperature of an object, but not for simply cooling (chilling) an object. The inside of the chamber 11 which is in a vacuum state is thus essentially retained at a very low temperature, so that the electrode plate 17, etc. is substantially heated up by the chiller.

The electrode plate 17 has a plurality of holes 17a for introducing the process gas into the chamber 11. In this structure, the electrode plate 17 is one component onto which the film is most likely to be adhered, and hence is one component which should firstly be cleaned among of the chamber member. Because of the structure that the electrode plate 17 includes the plurality of holes 17a, the electrode plate 17 can not easily be cleaned. By heating the electrode plate 17 using the chiller, the cleaning rate of the electrode plate 17 can partially be enhanced.

Example 7

The cleaning process is carried out on the following conditions, using the processing apparatus 10 of this embodiment which includes the lid member 29. In the film formation process, a SiOF film is formed in a thickness of 5 μm on a wafer W with the distance of 50mm between the electrodes. In the cleaning process, the cleaning gas at a ration of NF_3/Ar = 1000/1000 (sccm/sccm) flows at a pressure of 13Pa into the chamber 11. The temperature of the chiller flowing into the electrode supporter 18 and wall of the chamber 11 is set to 100°C. To obtain the experimental outcome, the chip on which the silicon oxide film is formed is provided on the electrode plate 17, and a reduction in the thickness of the silicon oxide film is measured.

FIG. 17 shows such experimental results. As seen from FIG. 17, as compared to the case where the electrode plate 17 is not heated, a high cleaning rate

at the electrode plate 17 can be obtained in the case where the electrode plate 17 is heated. According to the processing apparatus of the fifth embodiment, wherein the electrode plate 17 is heated, the cleaning rate can be enhanced at the electrode plate 17 which is difficult to sufficiently be cleaned, thus enabling to evenly perform the cleaning of the chamber 11. Further, by heating the wall of the chamber 11, the cleaning rate can highly be obtained throughout the chamber 11.

In the fifth embodiment, the walls of the electrode plate 17 and chamber 11 are heated by the chiller. However, the wall may be heated using any other methods.

For example, as shown in FIG. 18, instead of the chiller paths 31, a heater 32, such as a resistor, etc. may be included in the chamber 11.

As shown in FIG. 19, the walls of the electrode plate 17 and chamber 11 may be heated by a lamp 33, such as a halogen lamp, etc. In this case, a window 34 may be prepared on the side surface of the chamber 11, so that the electrode plate 17, etc. is heated by irradiating light thereto from the lamp 33 through the window 34.

FIG. 17 also shows results of cleaning experiments, respectively in the cases where the electrode plate 17 is heated by the heater 32 shown in FIG. 18 and heated by the lamp 33 shown in FIG. 19, in addition to the cases where the electrode plate 17 is not heated and is heated by the chiller. The heater 32 and the lamp 33 are set at 100℃.

As seen from FIG. 17, the electrode plate 17 is heated by the heater 32 or the lamp 33, to obtain a high cleaning rate at the electrode plate 17. Accordingly, the electrode plate 17 is heated, thereby enhancing the cleaning rate at the electrode plate 17 which can not sufficiently be cleaned.

In the fifth embodiment of the present invention, the temperature of the heater 32 or lamp 33 is set at 100℃. However, the temperature is not limited to 100℃, as long as the cleaning inside the chamber 11 can evenly be achieved.

In the above-described first to fifth embodiments, the SiOF film is formed on the wafer W, and the cleaning of the chamber 11 is done using an NF_3 gas, in the

parallel-plate-type plasma processing apparatus 10. However, the film to be formed is not limited to the SiOF film, and a silicon-containing film, such as SiO_2, SiC, SiN, SiCN, SiCH, SiOCH, etc. may be formed. The cleaning gas may include, not only the NF_3 gas, but a fluorine-containing gas, such as CF_4, C_2F_6, SF_6, etc., or a chlorine-containing gas, such as Cl_2, BCl_4, etc. The present invention may also be applied to a processing apparatus wherein LCD (Liquid Crystal Display) devices are processed.

In the second to fifth embodiments, the cleaning gas is activated so as to generate plasma of the cleaning gas, especially containing radicals. However, by activating the cleaning gas, the active species, other than the radicals, may be employed, so as to perform the cleaning of the chamber.

The present invention according to the second to fifth embodiments is applicable, not only to the parallel-plate-type plasma processing apparatus, but any other type of plasma processing apparatus, such as an ECR-type processing apparatus, an ICP-type processing apparatus, a helicon-type processing apparatus, a micro-wave-type processing apparatus, etc. In addition, the present invention is applicable not only to the plasma processing apparatus, but any other processing apparatus, such an etching apparatus, a sputtering apparatus, a heat processing apparatus, etc.

Industrial Applicability

The present invention mentioned above is useful for manufacturing semiconductor products.

This application is based on Japanese Patent Application No. 2000-239426 filed on August, 8, 2000 and including specification, claims, drawings and summary. The disclosure of the above Japanese Patent Application is incorporated herein by reference in its entirety.

CLAIMS

1. A processing apparatus (10) comprising:

a chamber (11);

a gas source (SA) for supplying a gas for cleaning inside of said chamber (11);

a gas line (L1) for introducing the gas supplied from said gas source (SA) into said chamber (11);

an activator (12) which is prepared in said gas line (L1) and activates the gas supplied from said gas source (SA); and

at least three gas inlets (28) which are provided at a side wall of said chamber (11) and connected to said gas line (L1).

2. The processing apparatus (10) according to claim 1, wherein said at least three gas inlets (28) are provided at equal intervals.

3. The processing apparatus (10) according to claim 1, wherein said processing apparatus (10) includes a plasma generation mechanism for providing a target object with plasma processing in said chamber (11).

4. The processing apparatus (10) according to claim 1, wherein said activator (12) generates plasma of the gas.

5. A processing apparatus (10) comprising:

a chamber (11);

a gas source (SA) for supplying a gas for cleaning inside of said chamber (11);

a gas line (L1) for introducing the gas supplied from said gas source (SA) into said chamber (11);

an activator (12) which is prepared in said gas line (L1) and activates the gas supplied from said gas source (SA); and

a gas inlet (28) which is provided on a surface of said chamber (11) and connected to said gas line (L1), and

wherein said gas inlet (28) is covered with a lid member (29) including at least one opening (30) having an area in a range between 50% and 80% of an area

of a main surface of the lid member (29).

6. The processing apparatus (10) according to claim 5, wherein said processing apparatus (10) includes a plasma generation mechanism for providing a target object with plasma processing in said chamber (11).

7. The processing apparatus (10) according to claim 5, wherein said activator (12) generates plasma of the gas.

8. A processing apparatus (10) comprising:

a chamber (11);

a gas source (SA) for supplying a gas for cleaning inside of said chamber (11);

a gas line (L1) for introducing the gas supplied from said gas source (SA) into said chamber (11);

an activator (12) which is prepared in said gas line (L1) and activates the gas supplied from said gas source (SA); and

a gas inlet (28) which is provided on a surface of said chamber (11) and connected to said gas line (L1),

wherein said gas inlet (28) is covered with a lid member (29) including at least one opening (30) which is provided diagonally with respect to a thickness direction of the lid member (29).

9. The processing apparatus (10) according to claim 8, wherein said processing apparatus (10) includes a plasma generation mechanism for providing a target object with plasma processing in said chamber (11).

10. The processing apparatus (10) according to claim 8, wherein said activator (12) generates plasma of the gas.

11. A processing apparatus (10) comprising:

a chamber (11);

a gas source (SA) for supplying a gas for cleaning inside of said chamber (11);

a gas line (L1) for introducing the gas supplied from said gas source (SA) into said chamber (11);

an activator (12) which is prepared in said gas line (L1) and activates the gas supplied from said gas source (SA); and

a heat mechanism for heating the internal surface of said chamber (11).

12. The processing apparatus (10) according to claim 11, wherein said heat mechanism includes a path (31) for chiller embedded in said chamber (11).

13. The processing apparatus (10) according to claim 11, wherein said heat mechanism includes a heater (32) which is embedded in said chamber (11).

14. The processing apparatus (10) according to claim 11, wherein:

said chamber (11) includes a window (34); and

said heat mechanism is provided outside said chamber (11) and includes a lamp (33) for irradiating light to the internal surface of the chamber (11) through the window (34).

15. The processing apparatus (10) according to claim 11, wherein said processing apparatus (10) includes a plasma generation mechanism for providing a target object with plasma processing in said chamber (11).

16. The processing apparatus (10) according to claim 11, wherein said activator (12) generates plasma of the gas.

17. A method for cleaning a processing apparatus (10) including two electrodes in a chamber (11), said method comprising the steps of:

introducing a gas for cleaning into said chamber (11); and

applying an RF power to each of the two electrodes (12, 17), thereby activating the gas for cleaning.

18. The method according to claim 17, wherein the gas for cleaning is activated to generate plasma thereof.

19. A method for cleaning a processing apparatus (10) including two electrodes (12, 17) in a chamber (11), said method comprising the steps of:

activating a gas for cleaning outside said chamber (11);

introducing the activated gas into said chamber (11); and

applying an RF power to at least one of the two electrodes (12, 17), thereby activating the gas for cleaning.

20. The method according to claim 19, wherein the gas for cleaning is activated to generate plasma thereof.

21. A method for cleaning a processing apparatus (10) including a chamber (11), said method comprising the steps of:

activating a gas for cleaning outside said chamber (11); and

introducing the activated gas into the chamber (11) in at least three ways.

22. The method according to claim 21, wherein said processing apparatus (10) provides a target object with plasma processing in the chamber (11).

23. The method according to claim 21, wherein the gas for cleaning is activated to generate plasma thereof.

24. A method for cleaning a processing apparatus (10) including a chamber (11), said method comprising the steps of:

activating a gas outside the chamber (11); and

introducing the activated gas into the chamber (11) in various directions.

25. The method according to claim 24, wherein said processing apparatus (10) provides a target object with plasma processing in the chamber (11).

26. The method according to claim 24, wherein the gas for cleaning is activated to generate plasma thereof.

27. A method for cleaning a processing apparatus (10) including a chamber (11), said method comprising the steps of:

activating a gas for cleaning outside the chamber (11);

introducing the gas into the chamber (11); and

retaining pressure in the chamber (11) in a range between 100Pa and 400Pa.

28. The method according to claim 27, wherein said processing apparatus (10) provides a target object with plasma processing in the chamber (11).

29. The method according to claim 27, wherein the gas for cleaning is activated to generate plasma thereof.

30. A method for cleaning a processing apparatus (10) including a chamber (11), said method comprising the steps of:

activating a gas for cleaning outside the chamber (11);

introducing the gas into the chamber (11); and

heating an inner surface of the chamber (11).

31. The method according to claim 30, wherein said processing apparatus (10) provides a target object with plasma processing in the chamber (11).

32. The method according to claim 30, wherein the gas for cleaning is activated to generate plasma thereof.

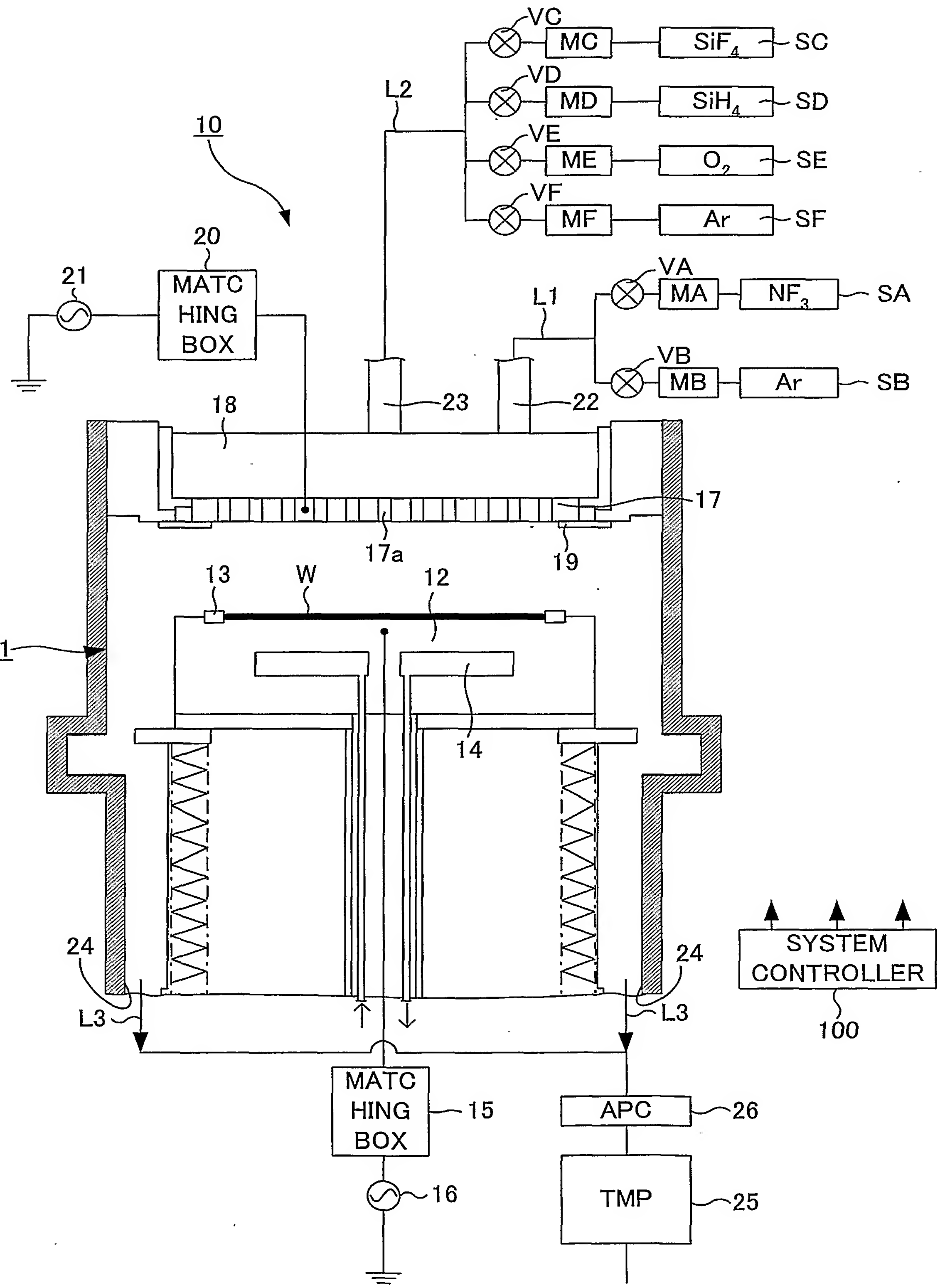
VC
MC
SiF4
SC
VD
MD
SiH4
SD
VE
ME
O2
SE
VF
MF
Ar
SF
L2
10
20
21
MATC HING BOX
VA
MA
NF3
SA
L1
VB
MB
Ar
SB
18
23
22
17
17a
19
13
W
12
11
14
24
L3
SYSTEM CONTROLLER
100
MATC HING BOX
15
APC
26
16
TMP
25

FIG.1

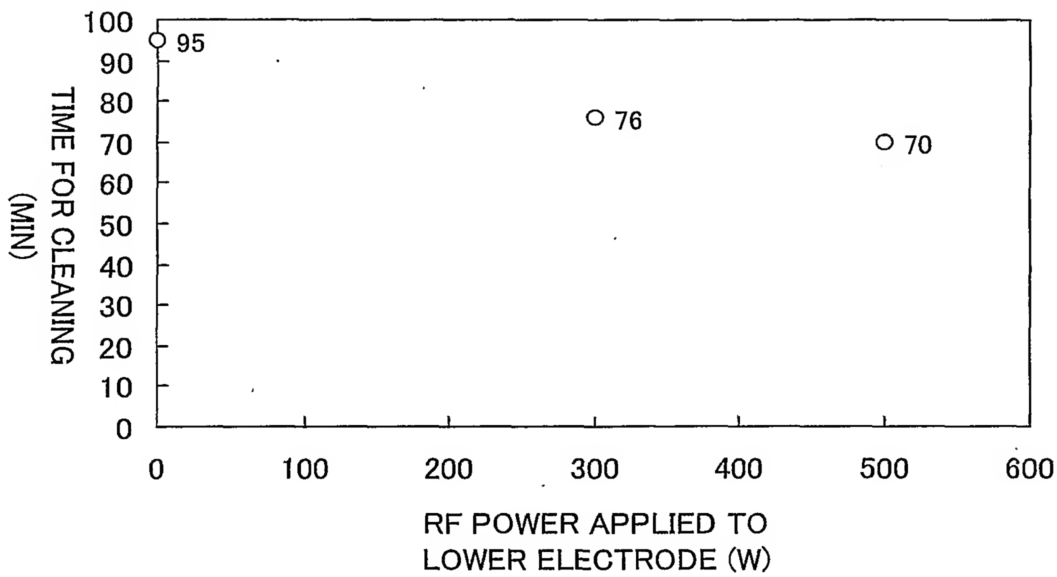
100
90
80
70
60
50
40
30
20
10
0
TIME FOR CLEANING
(MIN)
95
76
70
0
100
200
300
400
500
600
RF POWER APPLIED TO
LOWER ELECTRODE (W)

FIG.2

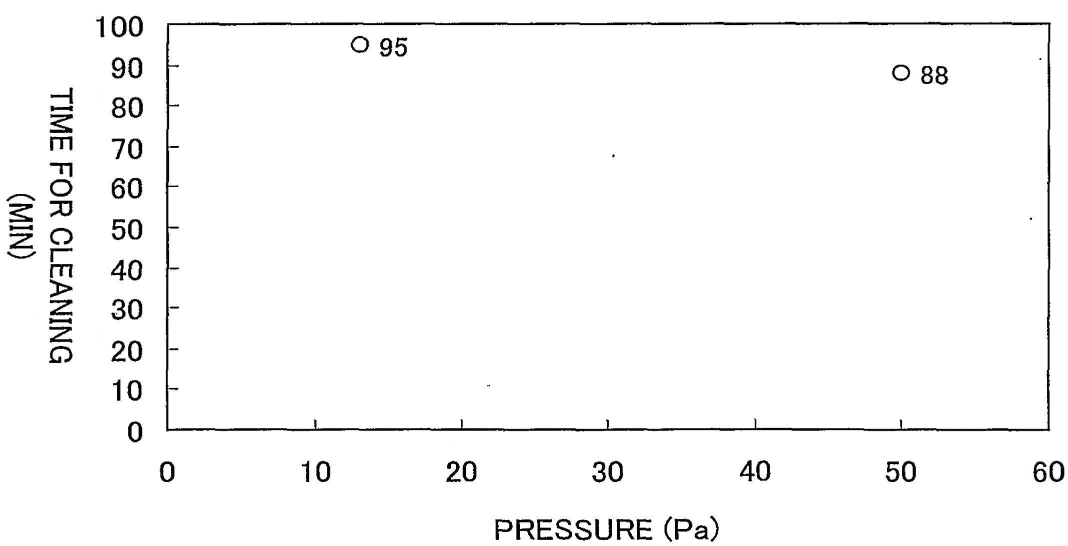
100
90
80
70
60
50
40
30
20
10
0
TIME FOR CLEANING
(MIN)
95
88
0
10
20
30
40
50
60
PRESSURE (Pa)

FIG.3

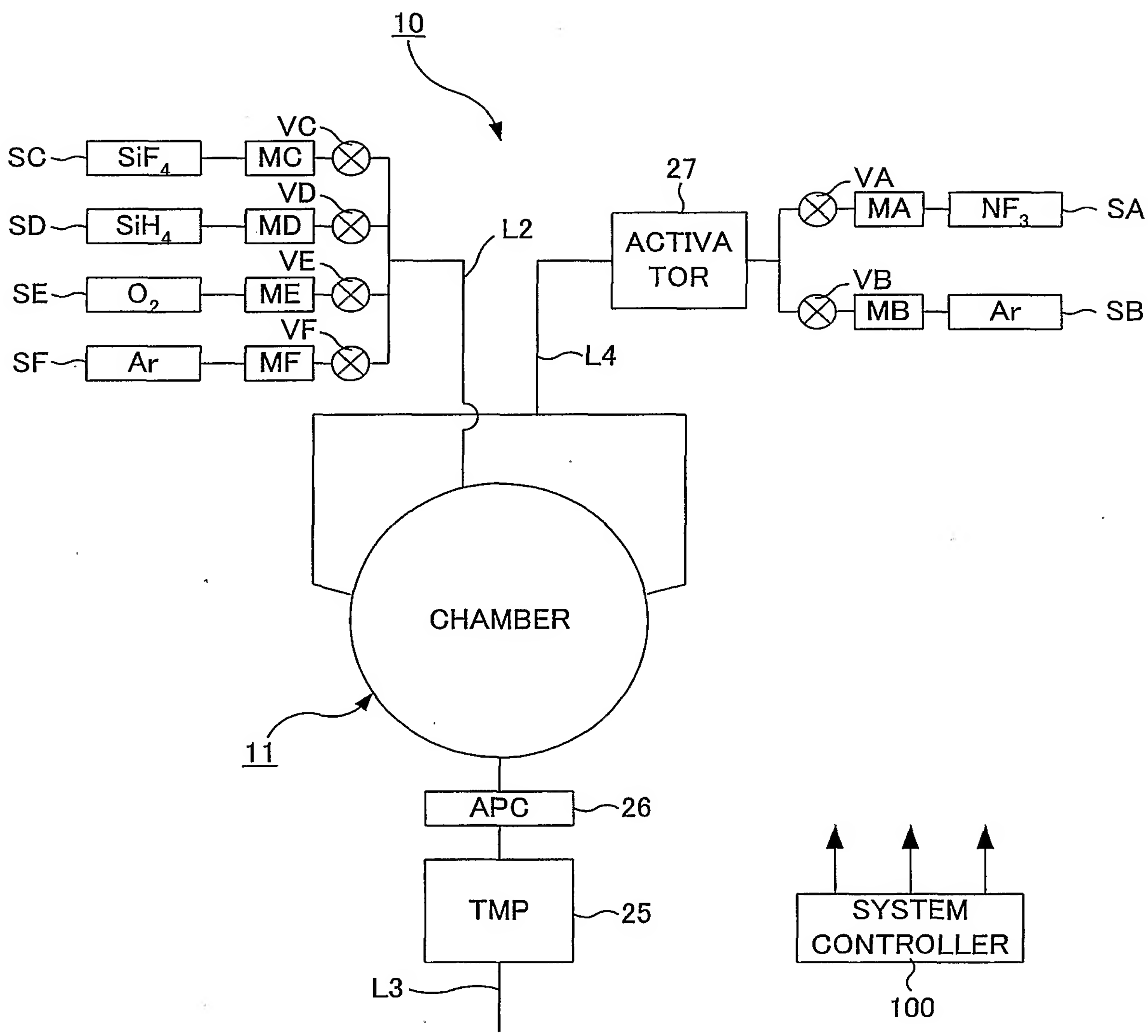
10
SC
SiF4
MC
VC
SD
SiH4
MD
VD
SE
O2
ME
VE
SF
Ar
MF
VF
L2
27
ACTIVA TOR
VA
MA
NF3
SA
VB
MB
Ar
SB
L4
CHAMBER
11
APC
26
TMP
25
L3
SYSTEM CONTROLLER
100

FIG.4

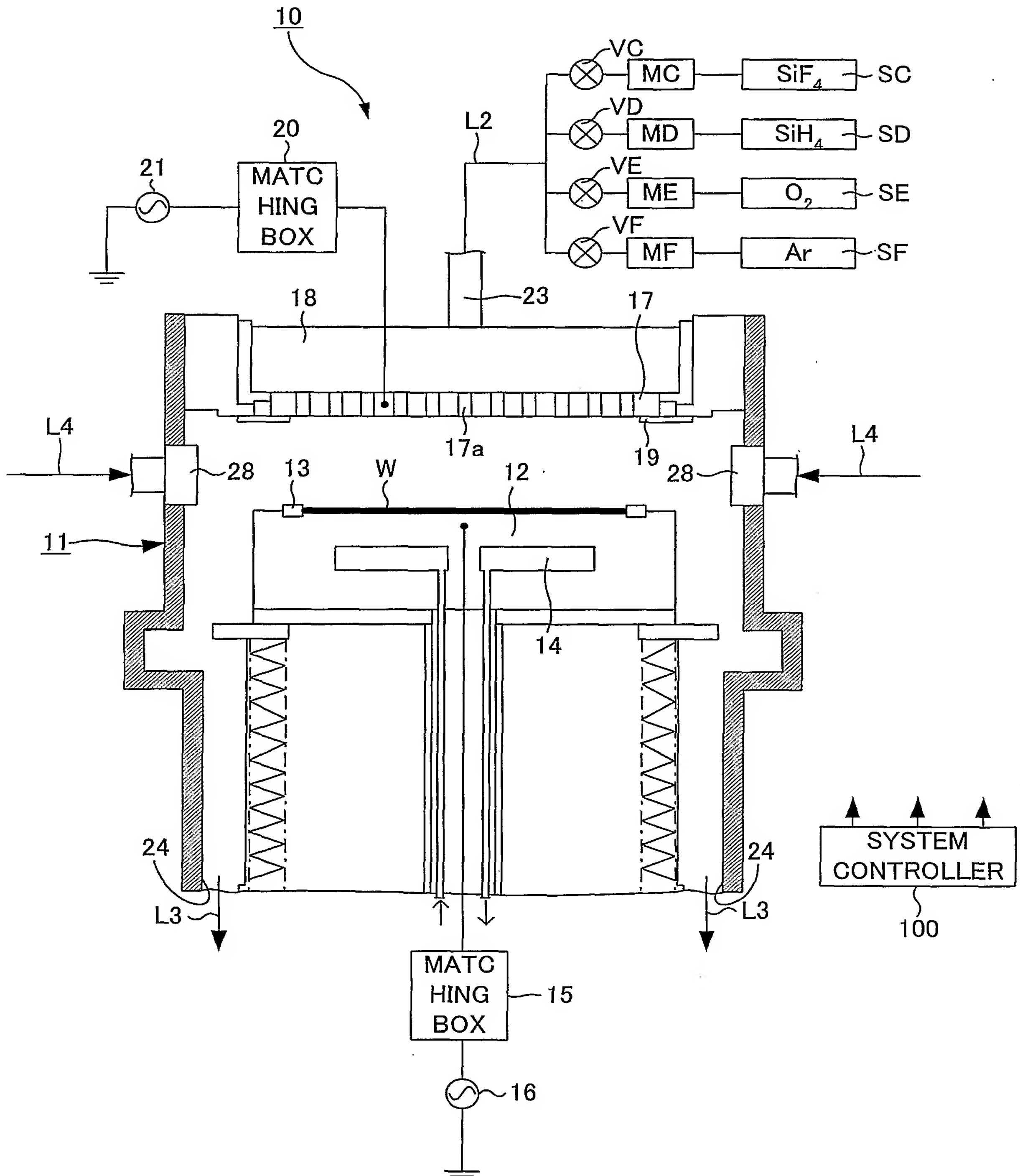
10
VC
MC
SiF_4
SC
VD
MD
SiH_4
SD
VE
ME
O_2
SE
VF
MF
Ar
SF
L2
20
MATC HING BOX
21
23
18
17
17a
19
L4
28
13
W
12
11
14
24
L3
SYSTEM CONTROLLER
100
MATC HING BOX
15
16

FIG.5

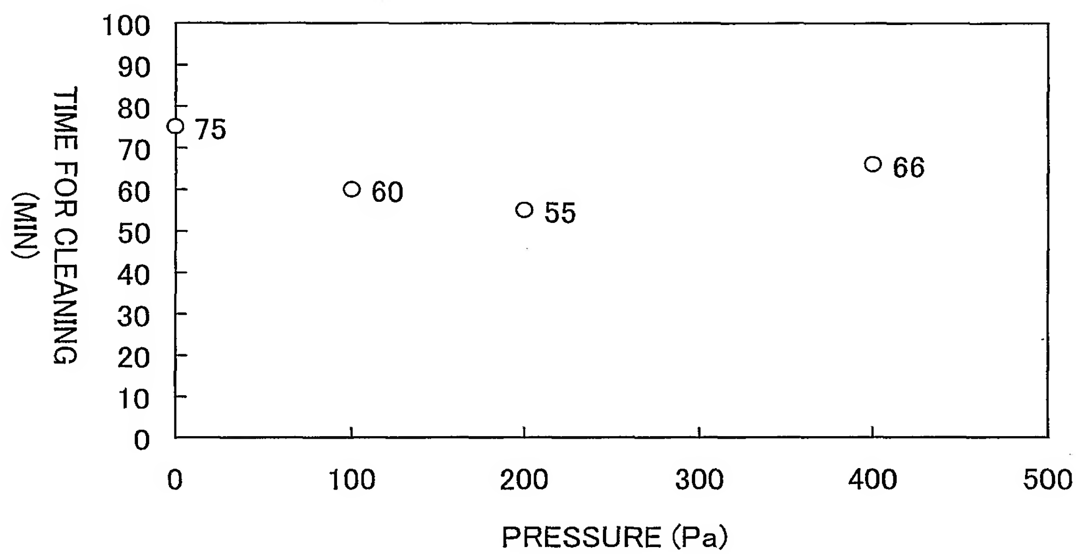
100
90
80
70
60
50
40
30
20
10
0
TIME FOR CLEANING (MIN)
75
60
55
66
0
100
200
300
400
500
PRESSURE (Pa)

FIG.6

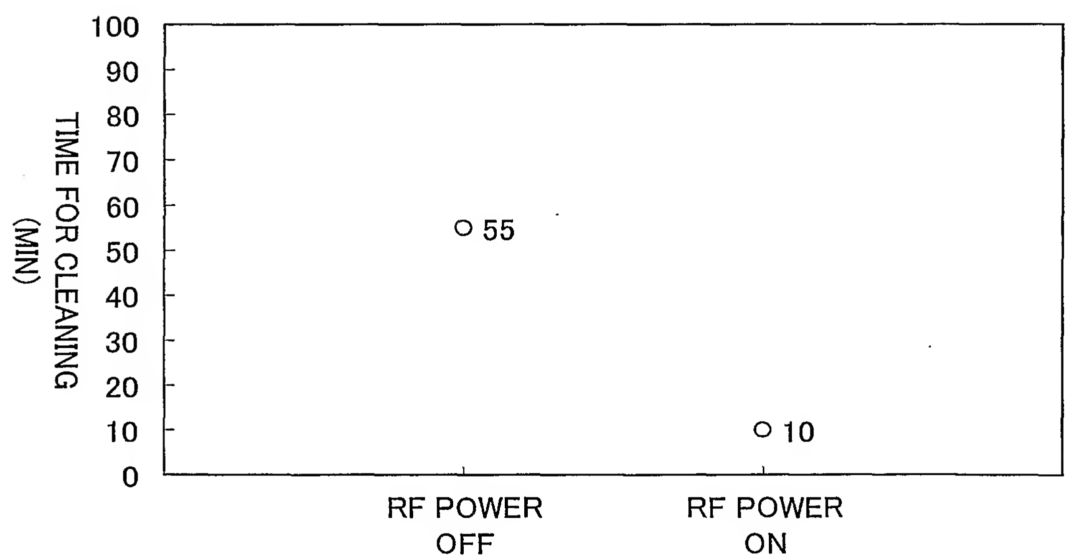
100
90
80
70
60
50
40
30
20
10
0
TIME FOR CLEANING (MIN)
55
10
RF POWER OFF
RF POWER ON

FIG.7

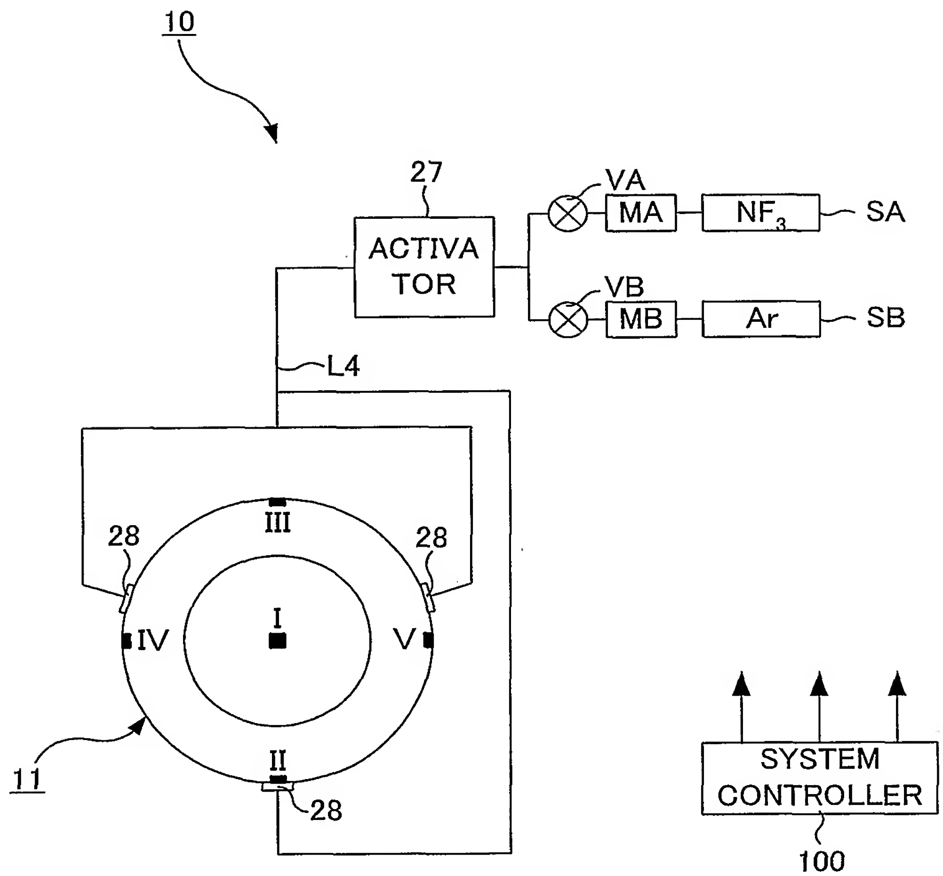
10
27
ACTIVA TOR
VA
MA
NF_3
SA
VB
MB
Ar
SB
L4
28
III
28
I
IV
V
11
II
28
SYSTEM CONTROLLER
100

FIG.8

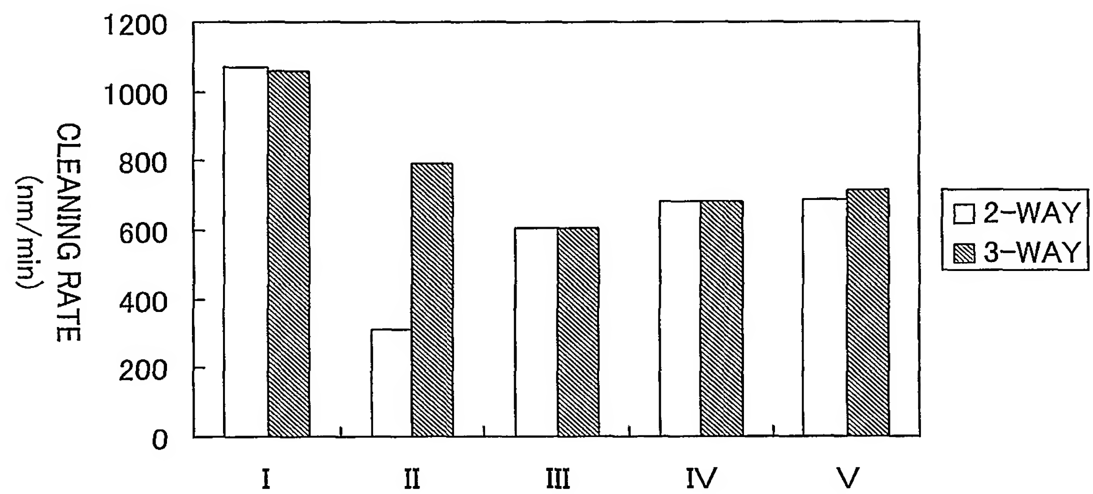
1200
1000
800
600
400
200
0
CLEANING RATE
(nm/min)
I
II
III
IV
V
2-WAY
3-WAY

FIG.9

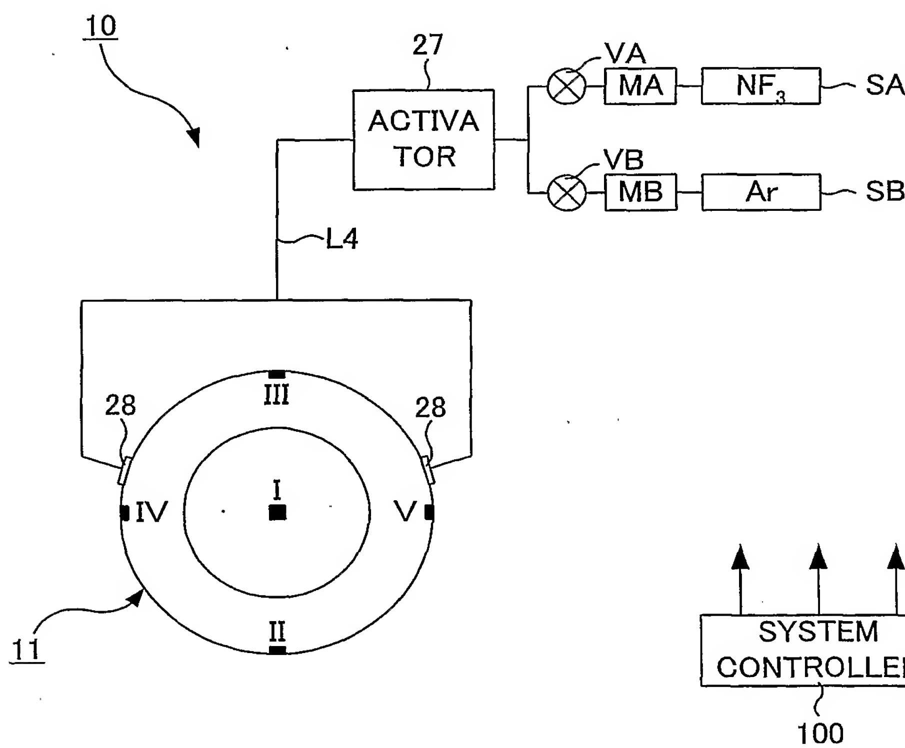
10
27
ACTIVA TOR
VA
MA
NF_3
SA
VB
MB
Ar
SB
L4
28
28
III
I
IV
V
II
11
SYSTEM CONTROLLER
100

FIG.10

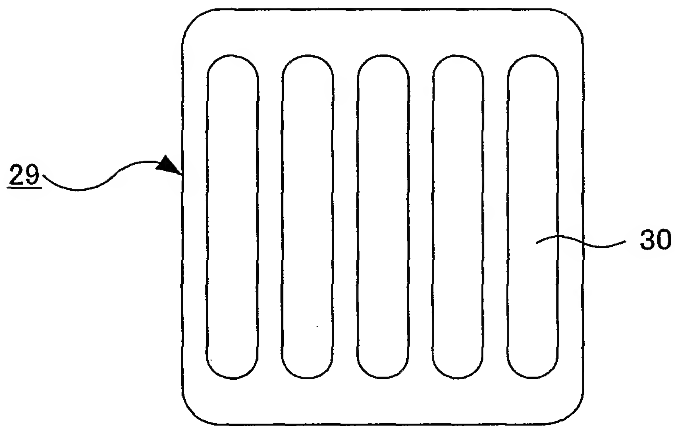
29
30

FIG.11

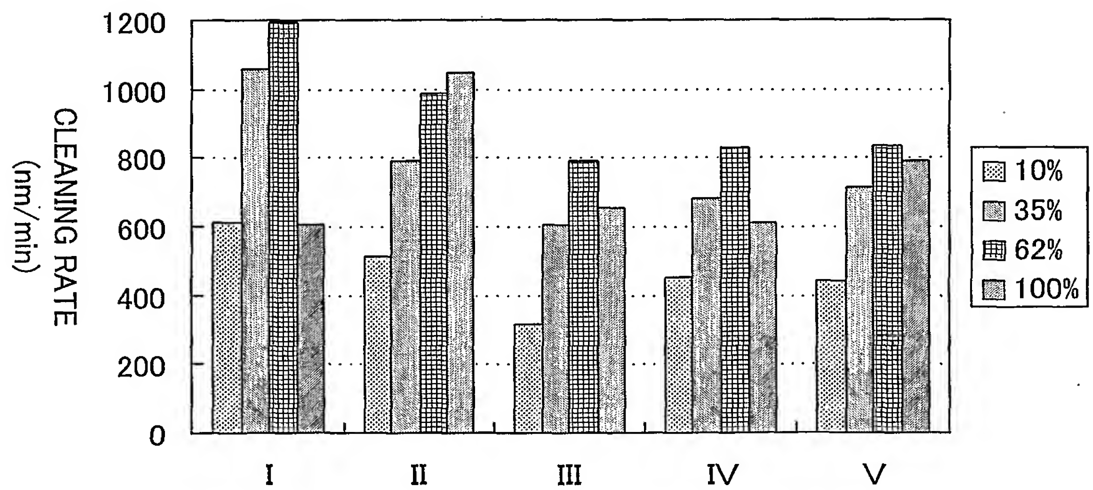
CLEANING RATE
(nm/min)
1200
1000
800
600
400
200
0
I
II
III
IV
V
10%
35%
62%
100%

FIG.12

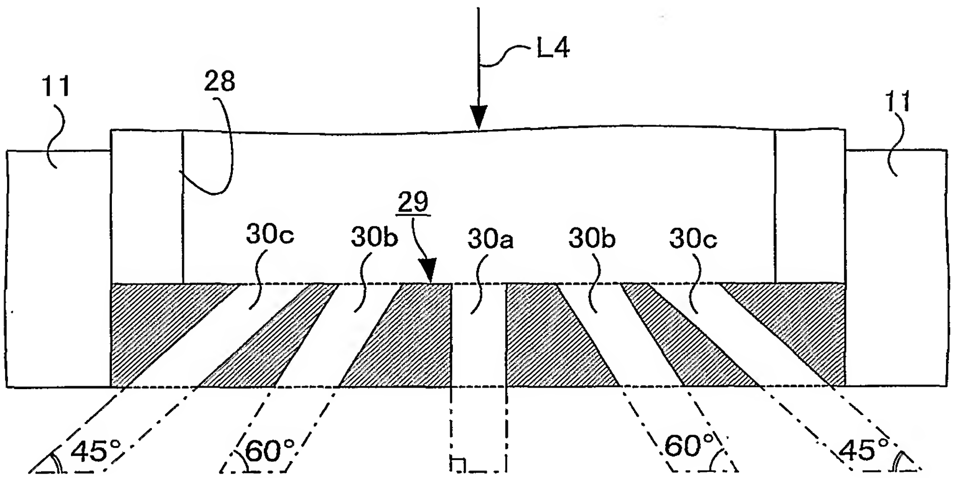

FIG.13

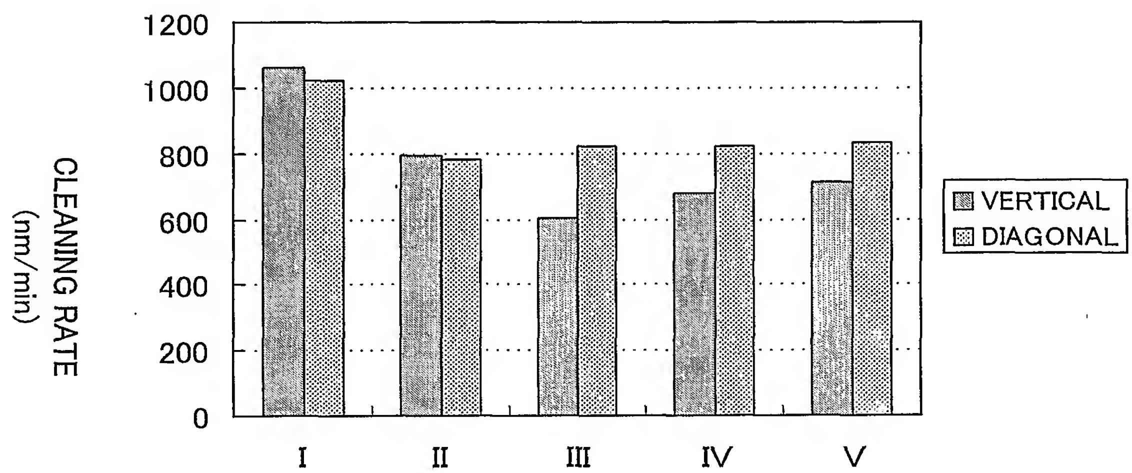
1200
1000
800
600
400
200
0
CLEANING RATE
(nm/min)
VERTICAL
DIAGONAL
I
II
III
IV
V

FIG. 14

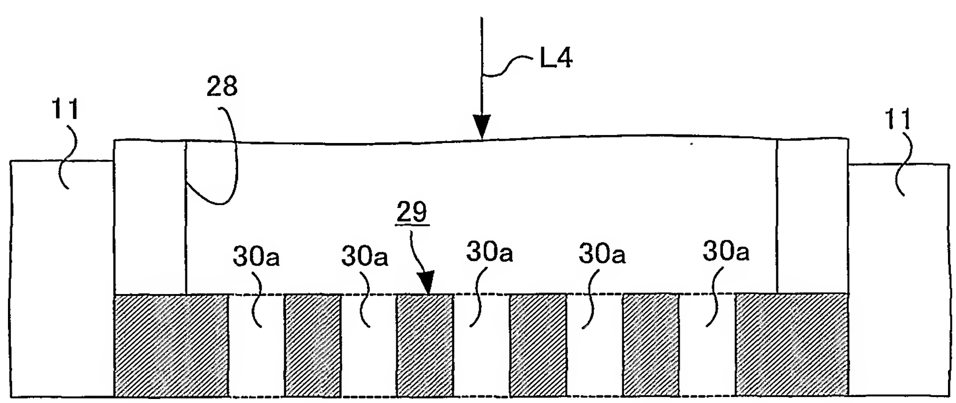
L4
28
11
11
29
30a
30a
30a
30a
30a

FIG. 15

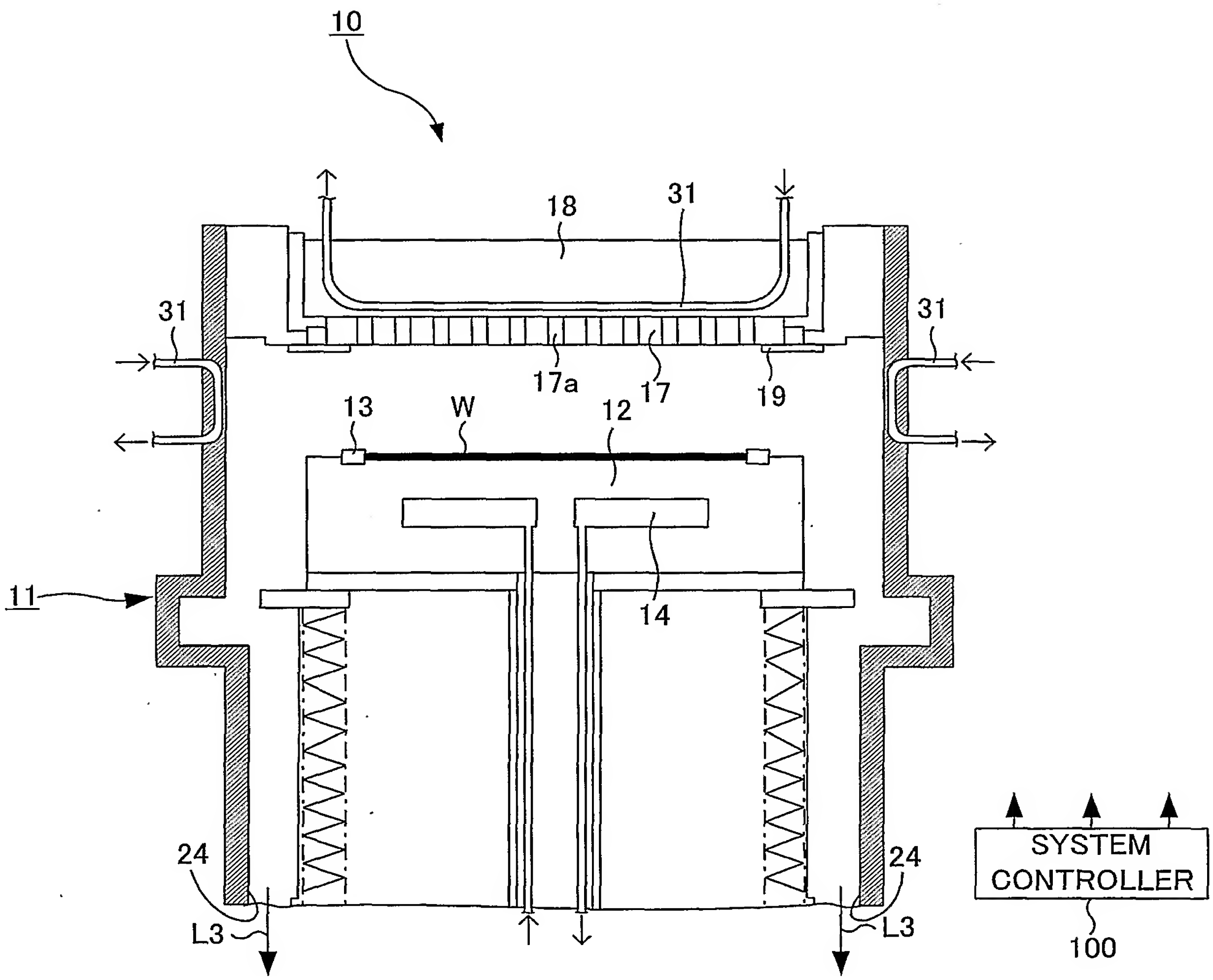
10
18
31
31
31
17a
17
19
13
W
12
14
11
24
24
L3
L3
SYSTEM CONTROLLER
100

FIG.16

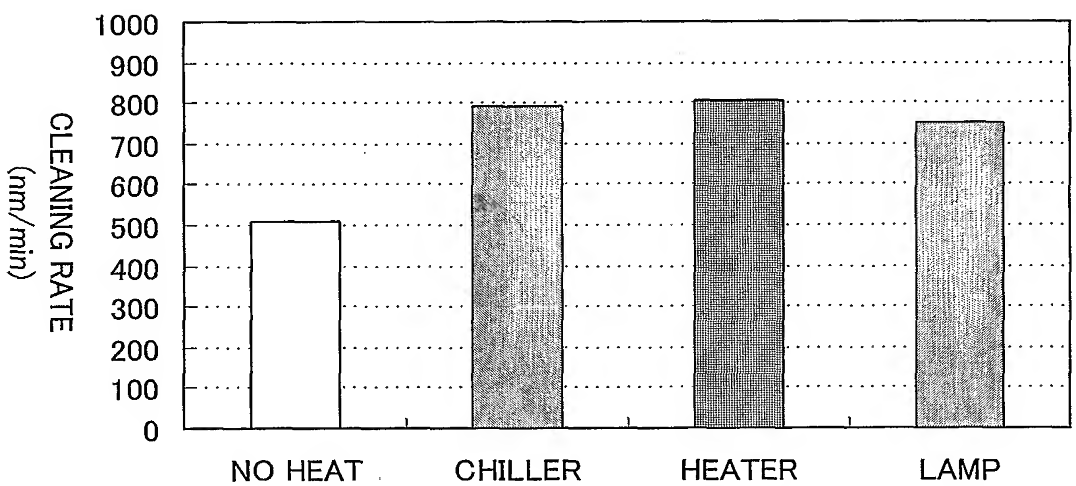
1000
900
800
700
600
500
400
300
200
100
0
CLEANING RATE (nm/min)
NO HEAT
CHILLER
HEATER
LAMP

FIG.17

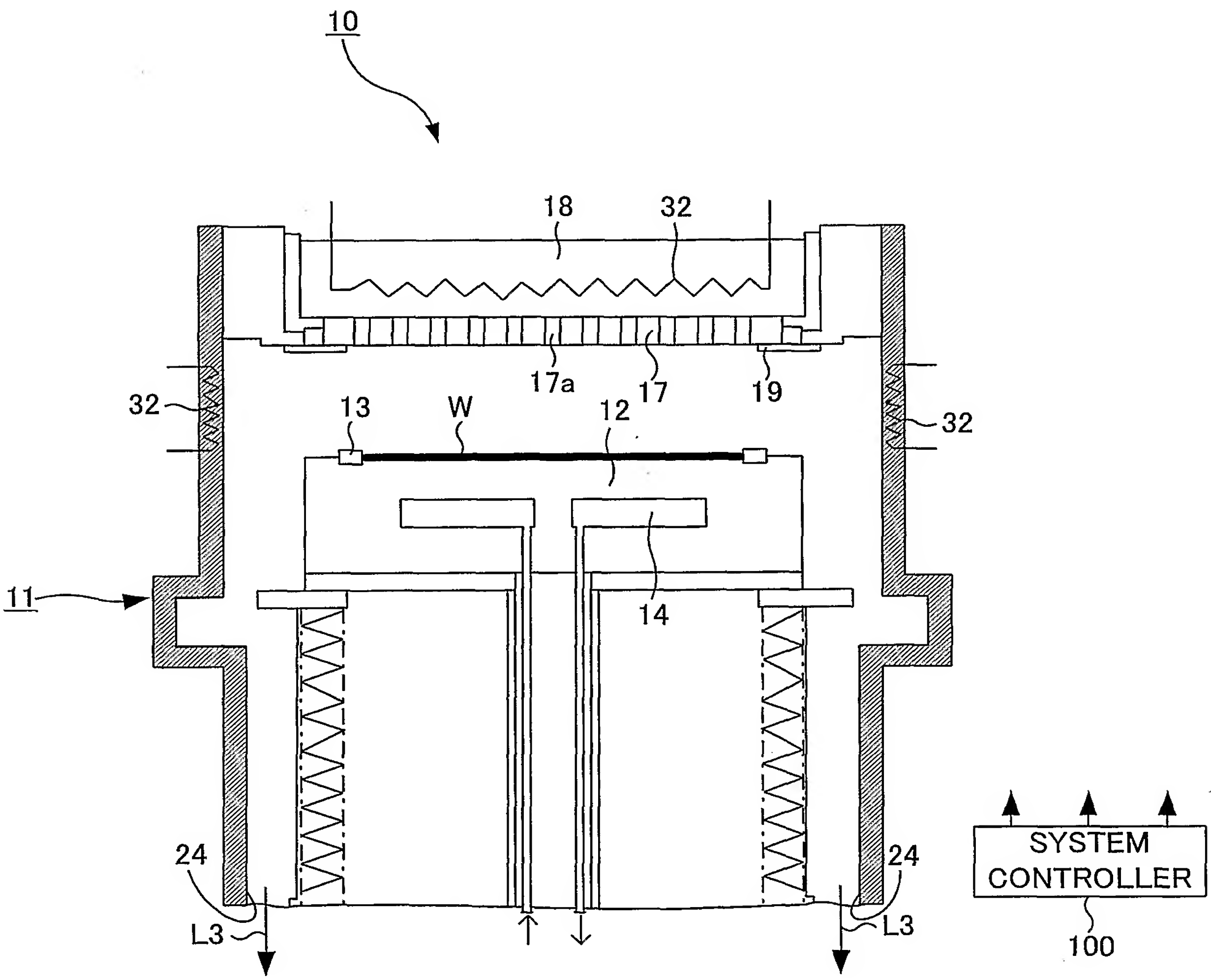
10
18
32
17a
17
19
32
13
W
12
32
14
11
24
24
L3
L3
SYSTEM CONTROLLER
100

FIG.18

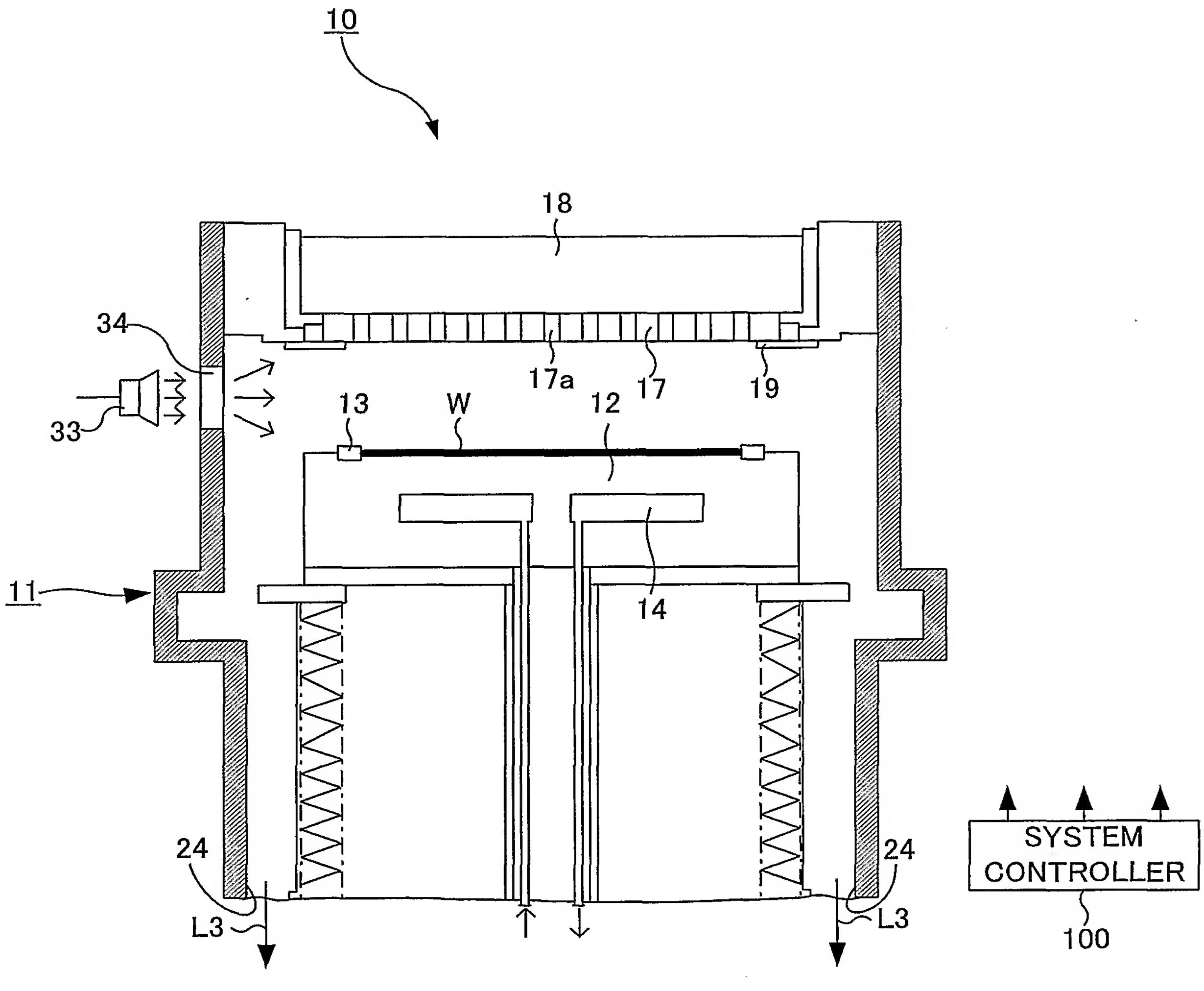
10
18
34
17a
17
19
33
13
W
12
11
14
24
24
L3
L3
SYSTEM
CONTROLLER
100

FIG. 19

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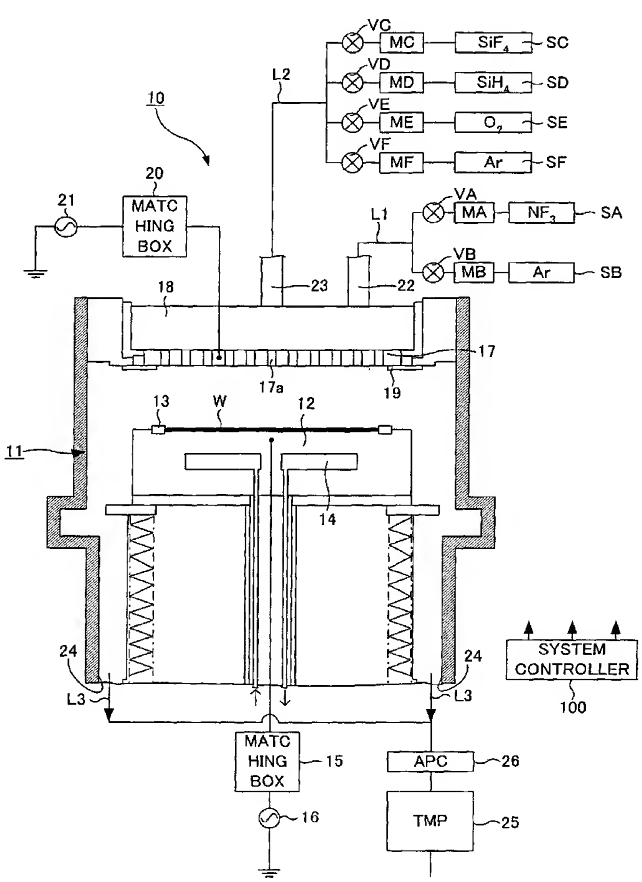
(81) Designated States *(national)*: KR, US.

(84) Designated States *(regional)*: European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR).

[Continued on next page]

(54) Title: PROCESSING APPARATUS AND CLEANING METHOD



(57) Abstract: Provided is a parallel-plate-type processing apparatus (10), which performs plasma CVD and includes a chamber (11) to be cleaned. To perform cleaning of the chamber (11), plasma of a gas including fluorine is generated outside the chamber (11), and supplied into the chamber (11). During the cleaning, an RF power is applied to electrode plates (12, 17) inside the chamber (11).

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Published:
— *with international search report*

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20 March 2003

INTERNATIONAL SEARCH REPORT

International Application No
PCT/JP 01/06784

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 C23C16/44 C23C16/452

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 C23C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ, WPI Data, IBM-TDB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 803 974 A (MASU KAZUYA ET AL) 8 September 1998 (1998-09-08)	1,2,4
Y	column 15, line 36 - line 52; figure 5	3

X	EP 0 697 467 A (APPLIED MATERIALS INC) 21 February 1996 (1996-02-21) cited in the application	21-23
Y	column 2, line 16 - line 36 column 4, line 14 -column 5, line 29 column 7, line 40 -column 8, line 2	3

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
6 February 2002	19. 07. 2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	EKHULT, H

INTERNATIONAL SEARCH REPORT

International Application No
PCT/JP 01/06784

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DATABASE WPI Section Ch, Week 197916 Derwent Publications Ltd., London, GB; Class L03, AN 1979-30514B XP002189339 -& JP 54 032184 A (TOKYO SHIBAURA ELECTRIC CO), 9 March 1979 (1979-03-09) abstract; figures 3,4 -----	1-4, 21-23

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP 01/06784

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-4,21-23

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-4,21-23

   Processing apparatus and cleaning method using more than three gas inlets.

2. Claims: 5-7

   A processing apparatus having a lid over a gas inlet with 50-80% opening.

3. Claims: 8-10,24-26

   A processing apparatus and cleaning method using a lid having diagonal openings.

4. Claims: 11-16,30-32

   A processing apparatus and cleaning method using chamber heating.

5. Claims: 17,18

   A cleaning method using RF power connected to two electrodes.

6. Claims: 19,20

   A cleaning method using both remote and in-situ plasma.

7. Claims: 27-29

   A cleaning method using a particular pressure range.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/JP 01/06784

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
US 5803974	A	08-09-1998	US	5753320 A	19-05-1998
EP 0697467	A	21-02-1996	EP	0697467 A1	21-02-1996
			JP	9069504 A	11-03-1997
JP 54032184	A	09-03-1979	JP	1008779 C	26-08-1980
			JP	54042956 B	17-12-1979